A New Method For Estimating Neutron Reaction Cross Sections Based on Wick's Limit

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The neutron reaction cross section σ_{reac}, also known as the nonelastic cross section, is important for applications but very difficult to measure accurately. In particular, obtaining σ_{reac} by subtracting the elastic from total cross sections is subject to large systematic and statistical errors. We present a new method for obtaining σ_{reac} based on such a subtraction, but in which the errors in the two terms are correlated by the use of Wick's limit, which relates the total and elastic cross sections. The reaction cross section may be written as a function of three independent quantities: σ_{tot}, the total cross section; F, the measured ratio of zero-degree differential elastic to angle-integrated elastic cross section; and η, the fractional deviation of the true zero-degree differential cross section from its Wick's-limit approximation. The resulting expression is

$$\sigma_{reac} = \sigma_{tot} - (1 + \eta)F(k/4\pi)^2\sigma_{tot}^2, \tag{1}$$

where k is the wave number of the projectile. The correlation between the two terms reduces the contribution to the error in σ_{reac} from σ_{tot} to a very small value. In practical cases the dominant error contribution is from F, and may be in the 1 to 2 % range. We have studied the range of validity of this method, which introduces a weak model dependence through the use of Wick's limit, by using a simple analytic (Ramsauer) model, as well as optical models. As an example, we have estimated the neutron reaction cross section on ^{208}Pb at 7, 20, 22, and 24 MeV as 2.393 ± 0.045, 2.477 ± 0.046, 2.538 ± 0.044, and 2.450 ± 0.044, respectively. These results used the elastic angular distributions reported by R. W. Finlay *et al.*, Phys. Rev. C**30**, 796 (1984). The resulting uncertainties are below 2%. Further examples of this technique will be shown.

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